ISSN 0704-3716

Canadian Translation of Fisheries and Aquatic Sciences

No. 5257

Food of the common seal (Phoca vitulina L.) and grey seal (Halichoerus grypus Fabr.) in Icelandic waters

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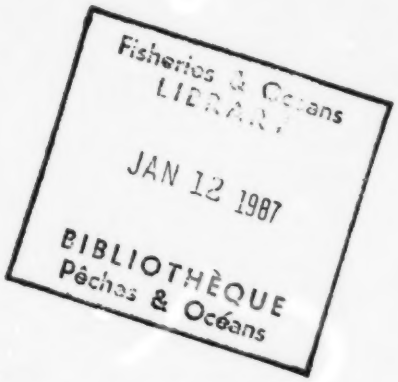
Original title: Faeda landsels og utsels vid Island

In: Hafrannsóknir 30: 27-64, 1984

Original language: Icelandic



Available from:
Canada Institute for Scientific and Technical Information
National Research Council
Ottawa, Ontario, Canada K1A 0S2

1986

57 typescript pages

90-02728/

Secretary of State / Secrétariat d'État

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

TRANSLATION BUREAU BUREAU DES TRADUCTIONS

LIBRARY IDENTIFICATION – FICHE SIGNALÉTIQUE

Translated from - Traduction de	Into - En
Icelandic	English

Author - Auteur
Hauksson, Erlingur

Title in English or French - Titre anglais ou français
Food of the common seal (Phoca vitulina L.) and grey seal (Halichoerus grypus Fabr.) in Icelandic waters

Title in foreign language (Transliterate foreign characters)
Titre en langue étrangère (Transcrire en caractères romains)
Faeda landsels og utsels vid Island

Reference in foreign language (Name of book or publication) in full, transliterate foreign characters.
Référence en langue étrangère (Nom du livre ou publication), au complet, transcrire en caractères romains.
Hafrannsoknir

Reference in English or French - Référence en anglais ou français
Marine Research

Publisher - Éditeur	DATE OF PUBLICATION / DATE DE PUBLICATION			Page Numbers in original / Numéros des pages dans l'original
	Year / Année	Volume	Issue No. / Numéro	27 – 64
Place of Publication / Lieu de publication				Number of typed pages / Nombre de pages dactylographiées
Iceland	1984	30		57

Requesting Department / Ministère-Client: DFO
Translation Bureau No. / Notre dossier nº: 2312169
Branch or Division / Direction ou Division: IPB
Translator (Initials) / Traducteur (Initiales): S.T.
Person requesting / Demandé par: N. Johnson
Your Number / Votre dossier nº:
Date of Request / Date de la demande: 03.06.86

Canada

SEC 5-111 (84-10)

Secretary of State | Secrétariat d'État

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

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Client's No.–N° du client	Department – Ministère	Division/Branch – Division/Direction	City – Ville
	DFO	IPB	
Bureau No.–N° du bureau	**Language – Langue**	**Translator (Initials) – Traducteur (Initiales)**	
2312169	Icelandic	S.T.	

Hafrannsoknir, vol. 30, pp. 27 - 64
1984

Hauksson, Erlingur :

FOOD OF THE COMMON SEAL (Phoca vitulina L.) AND THE GRAY SEAL (Halichoerus grypus Fabr.) IN ICELANDIC WATERS

Erlingur Hauksson

FOOD OF THE COMMON SEAL (PHOCA VITULINA L.) AND GREY SEAL (HALICHOERUS GRYPUS FABR.) IN ICELANDIC WATERS

Marine research vol. 30.

Published by Hafrannsoknarstofnun, the Icelandic Marine Research Institute. Skulagata 4, Reykjavik, Iceland

Editors:
Gudni Þorsteinsson
Eirikur Þ. Einarsson

Reykjavik
Hafrannsoknarstofnun
1984.

APPENDIX
Calculations of percentage of Greenland cod in the samples

In calculating the proportion of Greenland cod*) in the samples, it is taken as given that cod in the length group 40-69 cm are all Icelandic and not mixed with fish from Greenland. The calculations should then show the frequency of Phocanema larvae in Icelandic cod in the length groups 70-79cm, 80-89cm and >90cm. If it is taken as given that the Phocanema incidence rate is no higher than 1 % in Greenland cod, the percentage of cod from Greenland in these length groups can be found using the ratio infested/non-infested cod (see Platt, 1976). The calculations are based on solving the following equations which involve two unknown quant ties.

$$A_{1.1}X_1 + A_{1.2}X_2 = B_1$$

and

$$A_{2.1}X_1 + A_{2.2}X_2 = B_2$$

where $A_{1.1}$ is the incidence of Phocanema in Icelandic cod, length groups (40-69cm), $A_{1.2}$ is incidence of Phocanema in Greenland cod, $A_{2.1}=1-A_{1.1}$; $A_{2.2}=1-A_{1.2}$. B_1 is incidence of Phocanema in cod on Icelandic fishing grounds (the samples) mixed with cod from Greenland and $B_2=1-B_1$. X_1 is the percentage of Icelandic cod and X_2 is the

*) Greenland cod . Gadus ogac

percentage of cod from Greenland. The value of $A_{1.1}$ is 0.82; of $A_{1.2}$ 0.01; of $A_{2.1}$ 0.18; and of $A_{2.2}$ 0.99. B_1 and B_2 of the following length groups, and greenland cod then takes these values:

Alls is "Total"

	70-79 cm	80-89 cm	90 cm	Alls 70 cm
B_1:	0,65	0,48	0,64	0,59
B_2:	0,35	0,52	0,36	0,41
X_2:	0,21	0,42	0,22	0,28

The total number of Greenland cod collected in this survey therefore made up 28% of cod 70 cm and over in length; 42 % of cod in length groups 80-89 cm and 22% in the length group >90 cm.

INTRODUCTION

Seal samples were collected around the coast of Iceland for four years (1979-1982), for the purpose of examining various aspects of the biology of the Icelandic seal populations. Among them were samples from the digestive system, for determining feeding habits of seals.

The purpose of research on the food of seals is to increase our knowledge of the biology of seals in general, along with obtaining information on the relationship between food and nematode infestation. Research on the food of seals should also determine how much they eat of harvested fish species from Icelandic fishing grounds. This article will only review findings from the study that concerns the food of seals.

Bjarni Saemundsson (1932) was the first person to analyse food of seals around Iceland. Following in his footsteps, the biologists Jonbjorn Palsson (1977) and Jon Eldon (1977) did similar research for the Icelandic Seal Committee (Selanefnd),

along with the work of the ocean biologist Solmundur Einarsson (1978) at the Icelandic Marine Research Institute (Hafrannsoknarstofnun).

METHOD AND SOURCES OF DATA;

OBTAINING SAMPLES

A total number of 290 seal samples were collected; 193 from common seal (Phoca vitulina L:) and 97 samples from grey seals (Halichoerus grypus Fabr.) (Table 1)*. The samples were obtained from lumpsucker fishermen and traditional seal hunters, or we collected them ourselves. Most of the samples are from spring and summer, a few samples are from the fall months, while a serious lack exists of samples collected in winter. The samples come from various places along the coast, although most of them come from Breidafjordur bay (West Iceland, comm. transl.) and Vestfirdir (Northwest Iceland, comm. transl.). There are few samples from the south coast, and no grey seals samples at all from that area. The samples were frozen and kept in that state from the day of sampling, until they were analysed.

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*Please note that all tables and figures are at the back.
Comment from translator.

ANALYSING THE SAMPLES

The digestive tract was opened with a cut from one end to the other. The content of the digestive tract was washed through a 0.35 - mm filter and then stored in a 70 % isopropanol solution. The content of the digestive organs was analysed under a scanner, parasites were removed and stored in a 70 % isopropanol solution that included 5 % glycerol. All identifiable food pieces were analysed further; these were mainly solid parts of animal bodies; bones and otoliths of fish, the skin and shells of invertebrates. The otoliths were placed in groupes by fish species; their age determined; while the number of otoliths of each age group were also grouped together. The number of fish eaten was determined to be half the number of otoliths found. A total of 140 common seal and 85 grey seal samples were collected.

The weight of eaten fish was determined from the age of their otoliths or vertebras, using information on average weight of each age group. The average weight of each eaten individal of each species was calculated as the weighted average of the number of eaten individuals in each age group. The average weight of fish species by age is either obtained from sources on this matter, or estimated directly from information on the average length of fish by age groups through the use of the length-weight relationship of each fish species. When information is missing on the length and weight growth of the species, the average weight of eaten individuals is estmated from the weight of other species of similar size and body shape. Table 2 provides a list of the length-weight ratio of fish species in the food of seals, that were used for these calculations. The table has also a list of the average weights of the fish. As (published) information is lacking on the average length or the average weight of fish in the youngest age groups, this information is calculated (extrapolated) from available information on the general relation between age and length or the relation between age and weight of these fish species. The relation between length and age of the fish should then be the following:

$$l_t = L_\infty - (L_\infty - L_0) \cdot \exp(-kt)$$

Where l_t is the length at age t, L_0 is the length of the fish at age 0 and L is the maximum size of the fish (Crisp, 1971).

When estimating the weight of Ammodytidae* the diameters of the otoliths were measured and the average length of each Ammodytidae sample was, using the method of Macer (1966), estimated from the average diameter of the otolith . When examining Ammodytidae, the numbers of otoliths were usually very large, so that part-samples* were usually taken for processing. The average weight was calculated according to the length-weight relationship of *Ammodytes marines* Raitt, provided by fish biologist Vilhjalmur Thorsteinsson.

For redfish (Sebastes marinus L.), the length of the otoliths was measured, and the length of the fish was decided from the measurements of A. Kotthaus (1961). A. Kotthaus measured the relationship between the size of otoliths and the length of fish from redfish at East-Greenland, Iceland and the Faroe Islands. The weight of the redfish was estimated using the measurements of Dr. Jakob Magnusson, fish biologist , who provided the author of this paper with them.

When estimating the weights of lumpsuckers (Cyclopterus lumpus L.) that were found in the samples, it was taken as given that the seals did not swallow the head or the skin of this fish species (lumpsucker otoliths were usually not found in the samples). These body parts make up on the average 53.3 of the weight of male lumpsucker, and 40.1 % of the weight of

*Those would include Ammodytes marines Raitt, A. tobianus L. and possibly also the smaller Hyperoplus lanceolatus (Le Sauvage).

*The author is saying that only a part of the samples were analysed. Comment from translator.

the female (Pall Petursson and Arni Jonsson, 1972). It was also taken as given, that the seals had only eaten female lumpsuckers, which was confirmed by the fact that fish eggs were usually in the samples that showed traces of lumpsucker. Vilhjalmur Thorsteinsson assisted in determining the age of the lumpsuckers that were located (annual rings in vertebras were used); he also provided information on the probable total weight of these same lumpsuckers. It was estimated that the seal had eaten on the average 40 % of this weight (Table 3).

The average weight of eaten fish of the family Cottidae was determined to be the same as was found to be the average weight of the sea scorpion (Myxocephalus scorpius L.) in the survey on nematode infestation of this species in 1981-1983 (table 3).

The average length of rockeel (Pholis gunnellus L.) was determined from the size of their otoliths; their length was converted into average weight according to a rockeel length-weight factor. This factor was found by Dr. Aevar Petersen, animal scientist at the Icelandic Museum of Natural History (Natturufraedistofnun Islands), in his research on samples of rockeel (Table 3).

The average weight of eaten individuals of other species had to be estimated. The average weight of eaten sea invertebrates had also to be estimated, with the exception of flying squid (*Todarodes sagittatus* Lamark), as findings were used from the survey of Einar Jonsson (1980) on the growth of

flying squid around Iceland. All the flying squids were from seal samples from Breidafjordur bay (West Iceland, comm. transl.) taken in summer (Table 3).

ANALYSING THE DATA

The following factors were calculated from the original data: t_i = the frequency of each food species (the number of samples where a specific food species was found), n_i = frequency of each food species in each sample and $\bar{p}_i$ = the average weight of each food species in the samples. Seal samples were not included unless food remains were found in them. It was taken as given, that all traces of food, found in the digestive tract, were from one and the same meal. An exception to this was, however, made in a few instances; food that had clearly been eaten at different times was then added together and handled as if it was from the same meal.

The food in the seal samples was compared by time of year, coastal area, and seal species. The frequency of each food species (T_i) was determined and its part in the total amount of food in terms of weight, was calculated (P_i);

$$T_i = t_i / \sum_{i=1}^{k} t_i \quad \text{og} \quad P_i = n_i \cdot \bar{p}_i / \sum_{i=1}^{k} n_i \cdot \bar{p}_i,$$

where k is the number of species.

It was examined statistically through the use of "G tests" (Sokal & Rhohlf, 1981), if the frequency of food species in the samples could be dependent upon time of year, coastal area or seal species, where frequency was sufficiently high to make a test possible.

The make-up of food in the digestive tract of a seal species is compared using the Jaccard factor:

$$JS = (c/(a + b + c))100,$$

Where a is the number of food species found only in common seal, b is the number of food species found only in grey seal and c the number of food species found in both seal species (Sneath & Sokal, 1973).

The make-up of food of a seal species in terms of weight, is compared using the "FSI, Food similarity index *Shorygin*" (Windell, 1971). The factor indicates how similar the choice of food of the two species is; it ranges from 0 to 100% . The factor is determined as a percentage of each food species for

each seal species, and is compared with the lowest values added up for all the food species and food groups. This can be described by the following:

$$FSI = \sum \min (p_{xi}, p_{yi})$$

where p_{xi} is the percentage of the food species i for common seal and p_{yi} is the percentage of the same food species for grey seal (see Thoman, 1983).

The age distribution of food species in samples from common seal and grey seal is compared with X^2-square (Sokal & Rohlf 1981).

Food species were ranked according to how frequently they appeared, both in terms of percentage by frequency and percentage by weight, calculated out of the total amount of food consumed. A "Spearman rank correlation" factor (r_s) was used for this purpose (Sokal & Rohlf, 1981).

FINDINGS

COMMON SEAL

Sandeel (Ammodytidae) proved to be the most common food species in the digestive tract of common seal. Remains of this species were found in over 60 % of the seal samples and their percentage by frequency was 21 %. The next most common remains were those of cod (Gadus morhua L.) found in 40 % of samples and their percent. by frequency was 13.5 %, then came pollock

(Pollachius virens L.) found in 18% of all samples, percent. by frequency 6 % (see fig. 1). The food species and groups that were found in over 10 % of samples and had a percent. by frequency higher than 3.5 % were: capelin (Mallotus villosus (Muller))., dab (Limanda limanda L), other invertebrates; the group "small invertebrates", and finally the group "remains of algae".

In terms of percent. by weight, saithe is the most important species with over 30 %, followed by cod with 24 %, Ammodytidae, Merlangius merlandus L., and catfish (Anarhichas lupus L.) accounted for 5% (see fig. 2).

A statisticly significant difference was not found for food species of common seal between coastal areas. The exceptions to this were, however: saithe which is most common in samples from Faxafloi bay (Southwest Iceland, comm. transl.), capelin which is most common in the area Eyjafjordur fjord to Thistilfjordur fjord (written in Icelandic Þistilfjordur, comment from translator) (North Iceland) and *Pleuronectes platessa* L. which is just a little more common in samples from Breidafjordur bay (West Iceland, comm. transl.) than in other areas (see table 4 and 6).

In terms of time of year, statistical analysis found saithe and herring to be most common in food samples at the latter part of winter, capelin to be most common in the spring, dab in the fall and Ammodytidae in the summer (Table 5 and 6).

The remains of individuals from the fish species found in the digestice tract of seals showed that small and immature fish were most common (see fig. 3).

GREY SEAL

The most common remains in the digestive tract of grey seal were those of Ammodytidae and cod, found in around and over 40% of the samples, percent by frequency 14.7 % . The food species and groups that exist in at least 10 % of the samples and also have at least the percent by frequency 5% are: "other invertebrates", saithe, dab, sea scorpion, cat fish, Hyas spp., the group "other fish", and "remains of algae" (see fig. 1).

In terms of weight cod makes up the largest proportion. Cod accounted for 22 % of total weight of the food, followed by sea scorpion, lumpsucker, and cat fish, all of which account for over or around 10 % of total food weight; and halibut (Hippoglossus hippoglossus (L.)), saithe, herring (Clupea harengus L.) and Ammodytidae, that accounted for at least 5 % of food weight (fig. 2).

A statistically significant difference was not found between food species and coastal areas of Iceland. The only exception to this was catfish, which was more common in the area Strandir-Skagafjordur fjord (Northwest Iceland) than other areas. (Fig. 4 and 6).

For time of year, it was found that lumpsuckers were more common in the food in the spring and summer than at other times of the year, and catfish was more common in the summer (Table 5 and 6). Fig. 3 shows the age distribution of the fish remains from the digestive tract of grey seal. As with the common seal, small and immature individuals make up the greatest part, with the exception of lumpsuckers.

A COMPARISON OF FOOD REMAINS IN THE DIGESTIVE TRACTS OF COMMON SEALS AND GREY SEALS

The food species found were a little more numerous in common seal samples than in those of grey seal; 34 compared with 26. The food species found in common seals but not grey seals were: megrims, Agonidae, ling (species of the Gadidae family), Buccinum spp., stickleback, salmonids, Norway pout, whiting. All of these food species were found in relatively small quantanties in the common seals and do not belong to those food species that are dominant in terms of frequency, number, or weight, with the possible exception of whiting. Whiting was only found in samples from the south coast, but as samples from grey seal are missing from this area, this difference is not statistically significant. No food species were

located in grey seal that were not also found in common seal. A comparison of the frequency of food species using the Jaccard factor shows that a 75.7 % similarity exists between the two seal species. On the average, 2.8 food species were found in each common seal and grey seal (table 7).

A statistically significant difference was found when comparing the frequency of specific food species of common seal and grey seal. A difference was found in the case of Ammodytidae and capelin, which were more common in common seal food, and lumpsucker, which was considerably more common in grey seal food (table 8). Otherwise the same food species were dominant for both seal species.

As percentage of total weight, the same food species also dominate for the seal species, namely saithe and cod (fig. 2); on the whole the choice of food of common seal and grey seal shows a 52 % similarity (FSI=52).

Grey seal appears to eat rather older and larger individuals of each food species compared with common seal (fig. 3 and fig. 4). A statistically significant difference exists for cod (x^2_4 = 46.31 $p<0.001$), saithe (x^2_2=100.81 $p<0.001$), plaice (x^2_2=10.77 $p<0.05$), haddock (Melanogrammus aeglefinus (L.)) (X^2_2=59.64 $p<0.001$), and Ammodytidae[1)] (X^2_{23}=196.75 $p<0.001$)[*)]. The average

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1) For the comparison, width of otoliths was used and not age distribution as practised in the other cases.

*) As it was not possible for me to copy statistical formulas exactly please refer to the original Icelandic text (p. 47). Comment from translator.

weight of fish species is also usually rather higher in the food samples from grey seals compared with common seals (table 2).

DISCUSSION
LIMITS OF THE DATA AND FACTORS THAT COULD INFLUENCE THE FINDINGS

The quality of the data on the food of each species depends; first, on the number of samples and secondly, on the quality of each sample. Variations by locality, time of year, and even between years can be expected. If the research is to be as effective as possible, samples must be taken over a period of a few years and the distribution of samples should be even between coastal areas and time of year . For a statistically significant difference to be found between factors, the number of samples that must be obtained is probably greater than is possible to collect from seals and other large mammals. At the start of a survey, it is difficult to estimate how many samples must be taken so that a "significant" overview is obtained of the food. However, this can to a great extent be seen when the analysis is "finished" in some sense of the word.

In order to evaluate this, in surveys on feeding habits, the following two methods are usually used:

1. It is observed how many important food species become added, when the number of samples is increased. When new food species no longer become added as the number of samples is increased, this implies that the number of samples is "sufficient".

2. The changes in the percentage by frequency and percent by weight of the most important food species are observed as the number of samples is increased. Sampling is considered "sufficient" when only small changes appear in these values as additonal samples are added.

When the objective is, as was the case in this study, to examine the food of each species on an annual basis (the main emphasis not being on examining differences in food between the seasons or locality) it is very important to get an equal amount of samples from every season and from all the coastal areas. This is more important than obtaining a high absolute number of samples (See Korschgen, 1971).

Sampling, as part of surveys, is still far from being perfect for examining the food of seal species around Iceland. It is my opinion that most of the important food species have already been located, although their value in the total makeup

of the food could change as more food species appear with further sampling (fig. 5 and table 9). The main problem with the survey is, however, that a shortage exists of grey seal samples from the south coast of Iceland, along with a great shortage of samples from the winter months.

A strong possibility exists that food remains in the digestive tract of seal are from one and the same hunting trip. The digestion of seals and other "warm-blooded" carnivores is rapid and the food does not stay for long in the stomach. Research on seals in zoos shows that they digest and absorb the food in an average period of 17 hours (from feeding til evacuation) (Prime, 1979). The daily behavior pattern of seals also appears to be, that they go hunting in the evening; and then, after each hunting trip, rest in the daytime ashore, or in the sea. Most of the seals sampled, had more or less empty stomachs. Under such circumstances food remains in the guts and the colon are usually from the same meal.

If a seal is caught just after it has hunted or when it is caught at the place where it feeds, it is most likely that in the colon the remains still exist of an older meal. Also, small otoliths, for example from Ammodytidae, herring, or capelin from an older meal could be mixed in with the seal's last meal. The reason for this is that the otoliths will have been detained in the digestive tract when they were caught in the internal membrames of the seal. On the other hand, these small otoliths could also be overlooked by the people analyzing

the samples, and the smallest ones could have gone through the filter (0.35 mm). It is difficult to say in what manner these things will, on the whole, even each other out. The total effect of these things is probably as a whole small and should have a minor effect on the percent. by weight measurements.

When dealing with large prey, such as large cod, halibut and lumpsucker, seals have been seen to eat only parts of it. They usually leave the head and tail of the fish along with the skin of lumpsuckers, or eat only the stomach along with the intestines. Food remains of this nature would then be completely digested, and no trace would be left below the lower part of the guts. Therefore, it can be expected that in a survey of this nature, the proportion of large fish in the food of seals would be underestimated. It can also be expected that the proportion of cartilaginous fish is also underestimated; as they do not leave solid parts such as bones, their bodies would be digested nearly completely (see Pitcher, 1980).

A has been described, samples are lacking from winter time, along with grey seal samples from the south coast of Iceland. The effect of this could be that the proportion of capelin in common seal diet is underestimated, while the proportion of Ammodytidae is overestimated. For grey seal, the proportion of lumpsucker is probably overestimated, while whiting could be underestimated. Whiting is fairly common in common seal samples from the south coast. Other food species are more evenly distributed along the coast and are found at all times of the

year; therefore, less changes should exist in percent by frequency. It should also be noted in this context that some of the samples were obtained from seals caught in lumpsucker nets, and this could have resulted in an overrepresentation of lumpsucker in grey seal food.

Small invertebrates made up a part of both common seal and grey seal food; Crustacea, Idothea, small shrimp, etc. It is likely that these are mostly from the stomach of fish eaten by the seals. This could lead to an overestimate of invertebrates in the seals' food. However, the seals probably consume flying squid and larger invertebrates.

Small otoliths from for example Ammodytidae, capelin, small herring and other small fishes, can be carried into the seal with food species such as cod, saithe, halibut or other carnivorous fish. This could lead to an overrepresentation in the estimate of the percentage of small fish in the seal's food. However, it is likely that this is not an important factor, and it is known that these species are in the far greatest of instances eaten by seals, both common and grey seals, as many samples included only these small fish species.

Research has shown, that the otoliths of fish are digested in the stomach and guts of seals, sometimes so that they disappear completely (Prime 1979). The danger exists especially that otoliths of small fish disappear completely, leading to an underestimate of the proportion of either fish that are small in size or fish that have small otoliths. This could lead to difficulties when analysis is made from a seal's diet,

especially when food is analysed from the colon. This can also have the effect of underestimating the age of fish, as the outermost annual rings on the otoliths may have been digested away. In addition to this an underestimation of the weight of Ammodytidae can also occur, as their weight is estimated from the wideness of otoliths in fish. Therefore, the danger exists that in surveys such as this one, the frequency of small fish species is underestimated and that their calculated weight, along with the weight of larger fish species, will also be underestimated. However, it is difficult to estimate the effect of this compared with the other error factors.

As was explained in the chapter on methods, the weight had to be estimated of some fish species, along with most of the invertebrates. The reason was that the average weight of individuals of these species is not known. This could affect the estimation of percent by weight division of food species in the seal's diet. The effect of this ise, however, probably minor, as these fish species only make up a small part of the diet, and the invertebrates are small.

PERCENT BY FREQUENCY AND PERCENT BY WEIGHT OF OF FOOD SPECIES

This survey has used two methods for analysing the data. First, by calculating percent. by frequency of each food species and secondly, by finding percent. by weight of each food species out of total weight of food (see the chapter METHODS). By calculating by weight, important information is obtained about

some of the seal's food. This method is especially useful when consumption of harvested fish species by seals and other sea animals, is to be determined. Both percent. by frequency and calculating by number of individuals, overestimate food species that are small in size, although the former method provides good information on the location of a species in the food chain (Hyslop, 1980).

When comparing findings between percent. by frequency and percent. by weight, a substantial difference appears. For common seal, Ammodytidae is in first place with 21.2 % of percent. by frequency of total seal food, while if the measurement "percent weight of total food" is used, it comes out in third place with 9.9 % (fig. 1 and fig. 2). For cod, both methods provide the same results. Cod is in second place with 13.5 % of percent. by frequency and 23.9 % of percent. by weight. The biggest difference appears for saithe; it is in third place for percent. by frequency, while being at the top of the list for percent. by weight. Other food species also take different places on the food list according to which of the two methods is used. On the whole, a statistically significant difference appears between the methods percent. by frequency and percent. by weight in terms of rank of food species on the food list (r_s=0.58, $p<0.01$).

For grey seal, the ranking on the food list does not change as much according to which of the two methods, percent. by frequency or percent. by weight, is used. The greatest

difference appears for the food group "other invertebrates", 13% (see fig. 1 and fig. 2). Cod is most important when percent. by weight is used and, along with Ammodytidae, cod is also at the top of the percent. by frequency list. Taken as a whole, a significant difference does not exist between the two methods in terms of rank on food lists (r_s=0.33, p> 0.05). Fig. 6 exhibits the ranking of the most common food species using both the percent. by frequency and percent. by weight methods. It is clear that the importance of species in the food differs according to which method is used. Percent. by frequency places the smaller food species, like invertebrates, high on the list; while the percent. by weight method places large food species, like catfish and halibut etc., high on the list. Fish like cod, capelin, Lumpenidae and Zoarcidae, dab and Ammodytidae get similar places on both lists.

This difference in findings between using the two methods for analysing samples, emphasizes that increasing the number of samples can influence findings. It should be expected, that percent. by frequency of food species would change considerably less than percent. by weight of food species, as the number of samples goes up (table 9). The greatest variance can be expected for the larger food species, which have a frequency rate relatively low but a high value in terms of percent. by weight (fig. 7). With fewer samples, these species are more likely to be either over- or underestimated in percent. by weight than the smaller species. This could explain the high place of saithe in percent. by

weight of total food weight for common seal. A further increase in samples would likely reduce its importance, as saithe was only found in around 18 % of common seal samples; however, when found it was always in great quantities. Sampling can also have an effect, as seen by the fact that saithe is more common (in a statistically significant manner) in samples from Faxafloi bay during wintertime than in other areas and at other seasons (table 6).

A COMPARISON WITH THE FINDINGS OF EARLIER RESEARCH ON THE FOOD OF SEALS AROUND ICELAND

Research has been done before on the food of seals around Iceland by biologists Jon Eldon (1977) and Jonbjorn Palsson (1977), along with Bjarni Saemundsson (1932)*) . Samples in the survey of Jon Eldon are limited to specific localities and specific time. The findings of this study are therefore only to a limited extent comparable with that study; only very few of the samples are from the same place and taken at the same time of year in the two studies. As Jon Eldon collected only excrement samples, his findings must be compared with findings from studies on seal food from the digestive tract. However, this should be taken with caution, as it is difficult to say if

*)Bjarni Saemundsson was a pioneer in oceanographic research in Iceland. Comment from translator

excrement samples are always comparable with intestine and stomach samples (see Pitcher 1980).

In Faxafloi bay (West Iceland, comm. transl.), the remains of food most commonly found in the digestive system of grey seals in this survey were cod and related species and lumpsucker (table 4), while in excrement samples from 1977 from Hvalseyjar islands (West Iceland, comm. trans.) the remains of Ammodytidae are most common. The excrement samples are from January and February. Only one grey seal sample taken in the same time period exists in this study; it was in fact taken in Vestfirdir (Northwest Iceland, comm. transl.) and the seal had eaten cod, dab, capelin and herring (table 5). In the excrement samples of common seals in Thjorsa river (South Iceland, comment from translator), taken in January and February 1977, remains of cod and related species, flat fish and Ammodytidae were most common (Jon Eldon 1977). These are the same species as were according to this study dominant in the food of common seals in January and February (table 5). During February 1977, in Breidafjordur bay (West Iceland) the remains of cod and related species and Ammodytidae were most common in the excrement of seals. According to the findings of this study, Ammodytidae and cod are the most common food species of common seal, while lumpsucker is most common for grey seal in Breidafjordur bay (table 4). Cod and related species are the most common species for seals during this time of year, along with dab and capelin (table 5). If a comparison of this survey

and the excrement samples from 1977 is to be taken as valid, it appears that no variation exists in the food they consume except that which can be explained directly by different time of sampling and different sampling methods. The main difference is that Ammodytidae samples are more common in grey seal samples from Hvalseyjar island in 1977 than in the food of grey seal from Faxafloi bay, according to findings of a survey on food of seals 1979-1982. However, it is doubtful that a real difference exists in the food of seals betweem now and then. It is more likely that the explanation is that samples are missing from Hvalseyjar islands in this survey, and that a general lack exists of samples from the winter months (see table 1).

The samples of Jonbjorn Palsson (1977) of remains of food from the digestive tract of common seals were taken from various places along the coast and are mostly from spring and summer months (table 1, p. 134 in Solmundur T. Einarsson, 1978). Their distribution according to time of year, is rather similar to the distribution of the common seal samples in this study, except that proportionally the samples of Jonbjorn Palsson were more numerous during the spring months compared with this study (table 1). If percent. by frequency of individual food species in the survey of Jonbjorn Palsson

(1977)[1] is compared with percent. by frequency of the same food species of this survey, the result is in general similar:

	Jonbjorn Palsson (1977)	This study
Cod and related species	23.3%	22.1%
Capelin	22.5%	5.1%
Ammodytidae	16.8%	21.2%
Flat fish	11.2%	11.7%

Capelin is much more common in the samples from 1977 compared with 1979-1982. The explanation for this difference is probably that (as mentioned) samples taken in the spring were much more common in the survey of Jonbjorn Palsson (1977), compared with this survey. This is in accordance with the findings in table 6, where capelin is (in a statistically significant manner) more common in samples taken in Mars and April compared with other times of the year. In fact capelin is also more common in samples from the area Eyjafjordur fjord to Thistilfjordur fjord (North Iceland, comm. translator) than in other coastal areas,

1) Percent frequency was calculated from information on frequency of samples that included each food species, see table I in Solmundur T. Einarsson, 1978.

which implies that locality where samples were taken in the 1977 survey, can also explain this difference to some extent (table 6).

THE SEAL'S CHOICE OF FOOD

The makeup of the seal's food is dependent on what is available in each locality at each time. "Seal's choice of food" implies their choice out of what is available in each situation. The choice of available food must be known if it is to be determined whether the seals are opportunistic or selective feeders. This information is rarely, at least in the case of marine animals, obtainable. Their choice of food must, therefore, be discussed in a general manner.

Findings from surveys done both in Iceland and abroad, appear to show that these seal species eat almost only fish (Boulva & McLaren, 1979; Goitsev, 1972, Jon Eldon, 1977; Jonbjorn Palsson, 1977, Rae, 1968 and 1973). Invertebrates found in the digestive tract of seals in this survey can for the most part be traced to the fish found in the seals. The exception to this is, however, flying squid. Even seal pups start in the first year to eat the same food species as mature animals. A substantial difference does not appear to exist between the food of young and mature seals.

Remains of algae were located a number of times in seals. It appears that algae are eaten directly and do not go into the seal through other food. However, it is unlikely that algae

are an important source of food for seals; it is not common in terms of frequency; algae are usually only found in small quantities; and they are also difficult to digest for carnivorous animals.

It is likely that seals are opportunistic feeders. Most of the seals had only 1-2 food species in their digestive tract (table 7), while they probably seek out places where they expect good prey (Jonbjorn Palsson, 1977). The species found in their digestive tract are mainly those that are common around the coast of Iceland. A good example of opportunistic feeding of seals is their consumption of flying squid. Flying squid is not common in Icelandic fishing grounds, but when it migrates to this country, it arrives in great quantities, at which time the seals eat a great amount of it.

The difference between the food of common seal and grey seal is apparently rather small. The main difference is that grey seals eat larger prey than common seal. Lumpsucker is one of the most important food of grey seal, while this fish species is rarely or never eaten by common seal. However, common seals eat more herring and capelin. This is in line with the fact that grey seals are considerably larger animals than common seals. Competition between the two seal species is probably not great. They do not, for example, breed at the same time of year; grey seal breeds in the summer while common seal breeds in the fall. Seals usually fast during the breeding period. In terms of percent by weight, the food is only 1/2 the same. Direct competition over food is probably greatest

between fully mature common seals and young grey seals (that have not reached their full size, comm. transl.), the reason being that their size is similar.

The main food of seals around the coast of Iceland appears to be immature fish and other small fish species, with the exception of lumpsucker, which should also be easy prey for seals. Animals large in size, can be expected to eat large prey. Mature grey seals are most likely to be able to handle large fish. This has been confirmed frequently by fishermen who have seen grey seals struggling with large prey at the surface of the water.

THE LOCATION OF COMMON SEAL AND GREY SEAL IN THE FOOD CHAIN OF THE SEA

Seals are an important top level carnivorous animal in the sea around Iceland (fig. 7). Seals make up the top level in the food chain of the sea around Iceland along with whales, porpoise, killer whales, dolphins, sperm whales, and carnivorous fish like large halibut, shark and dogfish. They have few enemies in nature; killer whale is the most important enemy.

Common seals and grey seals apparently seek their food at similar locations in the sea. Benthic fish and demersal fish[1] are the most important sources of seal food, while pelagic

1) Fish are divided into benthic fish and demersal fish according to strength of ties with the bottom in terms of feeding, adaptation of body and other things. Demersal fish are according to this not as closely tied to the bottom as benthic fish. Examples of the former would be; Ammoditae, cod, lumpsucker, redfish etc. while examples of the latter would be herring, catfish, flatfish etc.

species are the next most important source (table 10). When seal food is grouped by percent. by weight, benthic and demersal fish are again the most important food. The exception is, however, saithe *2) in the case of common seal. The main difference between the location of grey seal in the food chain of the sea is that saithe is a more important source of food for common seal than grey seal when the weight measurement is used, although the same is not the case for percent by frequency. Lumpsucker is also a much more important species for grey seal than common seal, both in terms of percent. by weight and percent. by frequency.

If these findings are compared with those from other areas of the North Atlantic, the position of these seal species in the ecological system of the sea appears similar; benthic and demersal species are most common, while next in importance are pelagic species. It then depends on the nature of the ecological system in each area, which fish species are the most common in the seal's diet. Around the coast of Scotland, species like whiting and saithe are the most common for common seal, while cod and salmon[1] (Salmo salar L.) are most common for grey seal. At the coast of Holland, Pleuronectes flesus L., whiting and herring are the main food species for common seal.

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*2) Saithe is here considered a pelagic species, as it's habits are all the way from birth typical of pelagic fish.

1) Salmonids were very rarely found in this survey. They were much less common than in the survey of seal food in the British Isles. The probable explanation of this is different methods of collecting samples. However, it is also likely that around Iceland the frequency of salmonids was underestimated, as the otoliths of salmonids are more vulnerable than those of ocean fish to becoming digested away in the seal's digestive tract (see Pitcher 1980).

At the southeast coast of England the common seal, however, eats mostly Buccinum spp., flatfish, and Gobiidae (see Bonner, 1982). In the Baltic, the most common fish species in the food of common seal are gadoid species and flatfish, and for grey seal, cod, herring and salmonids (Almkvist et al. 1980). At the east coast of Canada common seal lives mostly on herring, squid (Illex illecebrosus Lesueur) and flounder, while the grey seal lives on herring, cod, flounder, skates, squid and mackerel (Scomber scombrus L.) (Mansfield and Beck, 1977; Boulva and McLaren, 1979).

PREDATION OF SEALS ON HARVESTED FISH SPECIES

Many of the most important food species of seals around Iceland are harvested fish species. It is likely that seal have some effect on the population size of these species. However, it is hard to estimate how great this effect is. Seals eat mostly immature fish, and therefore their greatest impact is on the recruitment of new individuals into the fish stocks, especially the fish species cod, saith, and catfish. Therefore, in terms of these fish species, they compete with the fisheries of Iceland for fish catch. Lumpsucker are, however, an exception; the seals eat individuals of that fish species from the mature part of the stock, when the lumpsuckers come up to the coast to spawn. Mature individuals of small fish species, such as herring and capelin, are also eaten by seals.

Lumpsuckers, herring and capelin are therefore species that man and seals compete over directly.

Information must be obtained on the total food consumption of seals, if the effect of the seal stocks on the population size of harvested fish species is to be estimated. This makes it necessary to obtain information on the size of the common and grey seal stocks around Iceland, along with age distribution and growth. Research on these factors of the biology of Icelandic seals is now taking place. When that research is finished, it will be possible to evaluate the consumption by the seal stocks of harvested fish stocks in a clearer manner than has been possible until now (see Solmundur T. Einarsson, 1978).

CONCLUSION

More samples must be collected, especially in winter, if better information is to be obtained on the seal's choice of food. It is also necessary to have the study extended over a longer period than three years. However, important information has been obtained on the choice of food among seals from research done for the "Ringworm Committee" (Hringormanefnd) . Further research is necessary on the choice and consumption of

food among seals, if the effect of seals on the Icelandic fisheries is to be estimated and their role in spreading the ringworm *Phocanema decipiens* determinded.

ACKNOWLEDGEMENT

Special thanks go to the specialists at the Icelandic Marine Research Institute (Hafrannsoknarstofnun) for assistance in analysing otoliths and vertebrae and for providing information on the relation between length of fish, size of otolith and weight of fish of various fish species: Adalsteinn Sigurdsson, Dr. Gunnar Jonsson, Dr. Jakob Magnusson, Dr. Sigfus Schopka and Vilhjalmur Thorsteinsson. Thanks are also due to Solmundur Einarsson for providing 30 seal samples from 1979, and to others who provided seal samples for the surveys, as well as to Asbjorn Dagbjartsson, biologist, and researchers Lars Hansen and Gunnar Thorsteinsson for assistance in collecting and analysing samples.

The research of the food choice of seals around Iceland was done by the Ringworm Committee and paid by the Icelandic Freezing Plants Corporation (Solumidstod hradfrystihusanna), The Federation of Icelandic Co-operative Societies (Samband islenskra samvinnufelaga) Union of Iceland Fish Producers (Solusamband Islenskra Fiskframleidenda), Coldwater Seafood Corporation and Icelandic Seafood Corporation.

The Icelandic Marine Research Institute paid the expenses of publishing this article.

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ABSTRACT

Food of the common seal *(Phoca vitulina L.)*
and grey seal *(Halichoerus grypus fabr.)*
in Icelandic Waters

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In the period 1979–82 the content of the alimentary canal of 193 common seals and 97 grey seals was investigated for remains of food.

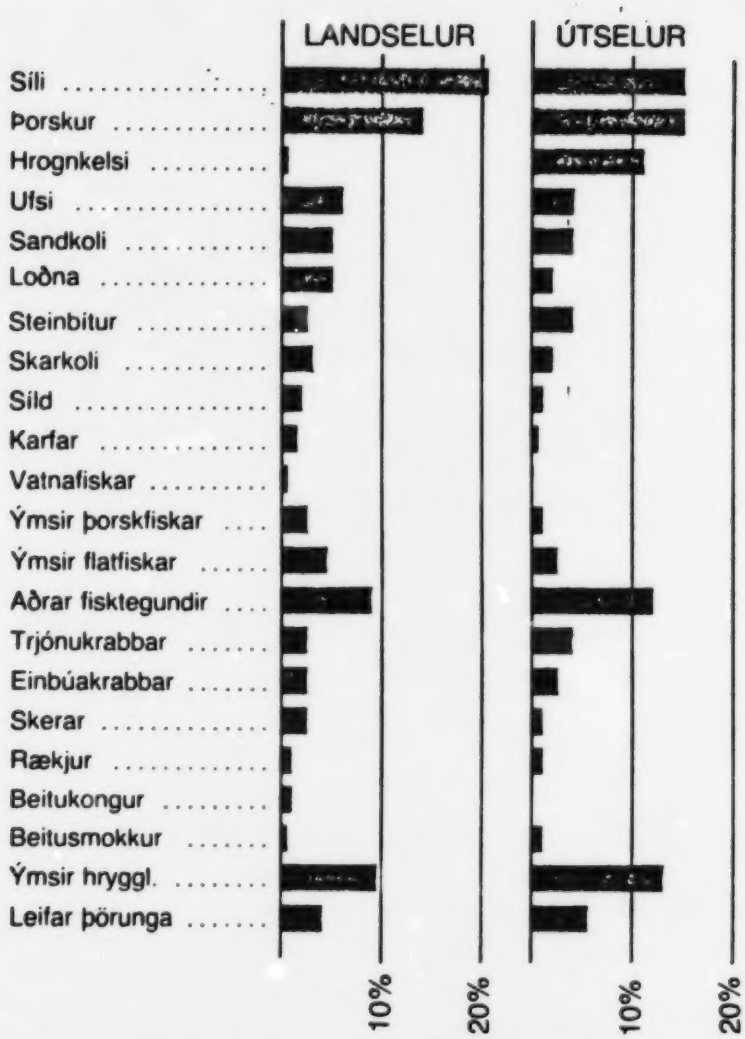
Remains of cod *(Gadus morhua* L.) and sandeel *(Ammodytes* spp.), were by far the most common, occuring over 40% of the samples of each seal species. Next in importance for the common seal as food species came saithe *(Pollachius virens* L.), capelin *(Mallotus villosus* (O. F. Müll.)) and dab *(Limanda limanda* L.) in this order. For the grey seal the order is lumpsucker *(Cyclopterus lumpus* L.), catfish *(Anarhichas lupus* L.), dab, saithe, sea scorpions *(Scorpiidae)* and spider crabs *(Hyas* spp.). These items all occur in over 10% of the samples of each seal species. They are all common foods of both species, except lumpsucker, which was found in only two common seals, but in over 30% of samples from grey seals. This seems to be the main difference in food selection of the two seal species.

In percent by weight of food, the most important food species of common seal is saithe (33.4%), then cod (23.9%), sandeel (9.9%) and whiting *(Merlangius merlangus merlangus* L.), catfish, dab, capelin, all over 2.5% in importance. The most important food species of grey seal by weight are: cod (22.0%), sea scorpions (12.6%), lumpsucker (11.9%) and catfish (11.1%). Then halibut *(Hippoglossus hippoglossus* L.), saithe, herring *(Clupea harengus harengus* L.) and sandeel with over 5% in importance.

Seasonal and regional differences of food remains in the animals indicate an opportunistic way of feeding. The seals feeding on the most common food species at each time and place. The results show that within the first year of life, the pups have already begun feeding on the same animal species as the older seals.

Together with the bigger carnivorous fishes and toothed whales, seals make up the bulk of the top carnivores in Icelandic waters. The seals seek food from most of the commercially important fish species, either by feeding on the parental stock, as in the case of lumpsucker, or by predating the recruits, as in the case of cod.

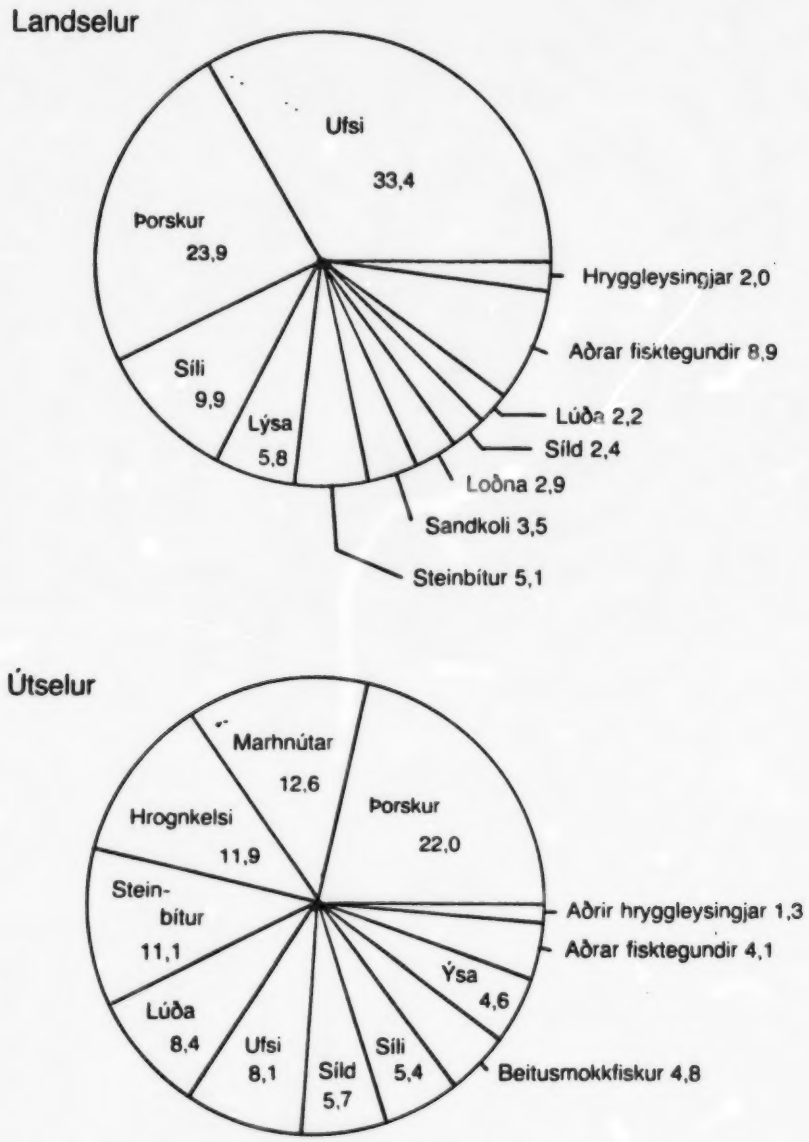
Fig. 1.



1. mynd. Fæða landsels og útsels. Hlutfallsleg tíðni fæðutegunda.

Food of common seal (Phoca vitulina L.) and grey seal (Halichoerus grypus Fabr.), in Icelandic waters, in percentage of the total occurrences of all food items. Landselur common seal, útselur grey seal, síli sandeel, þorskur cod, hrognkelsi lumpsucker, ufsi saithe, sandkoli dab, loðna capelin, steinbítur catfish, skarkoli plaice, síld herring, karfar red-fish, vatnafiskar freshwater fishes, ýmsir þorskfiskar various gadides other than already mentioned species, ýmsir flatfiskar various flatfishes, aðrar fisktegundir other fishes, trjónukrabbi Hyas *spp., einbúakrabbar* Lupagurus *spp., rækjur pandalides, beitukongur* Buccinum *spp., Beitusmokkur flying squid, ýmsir hryggl. various invertebrates, leifar þörunga remains of algae.*

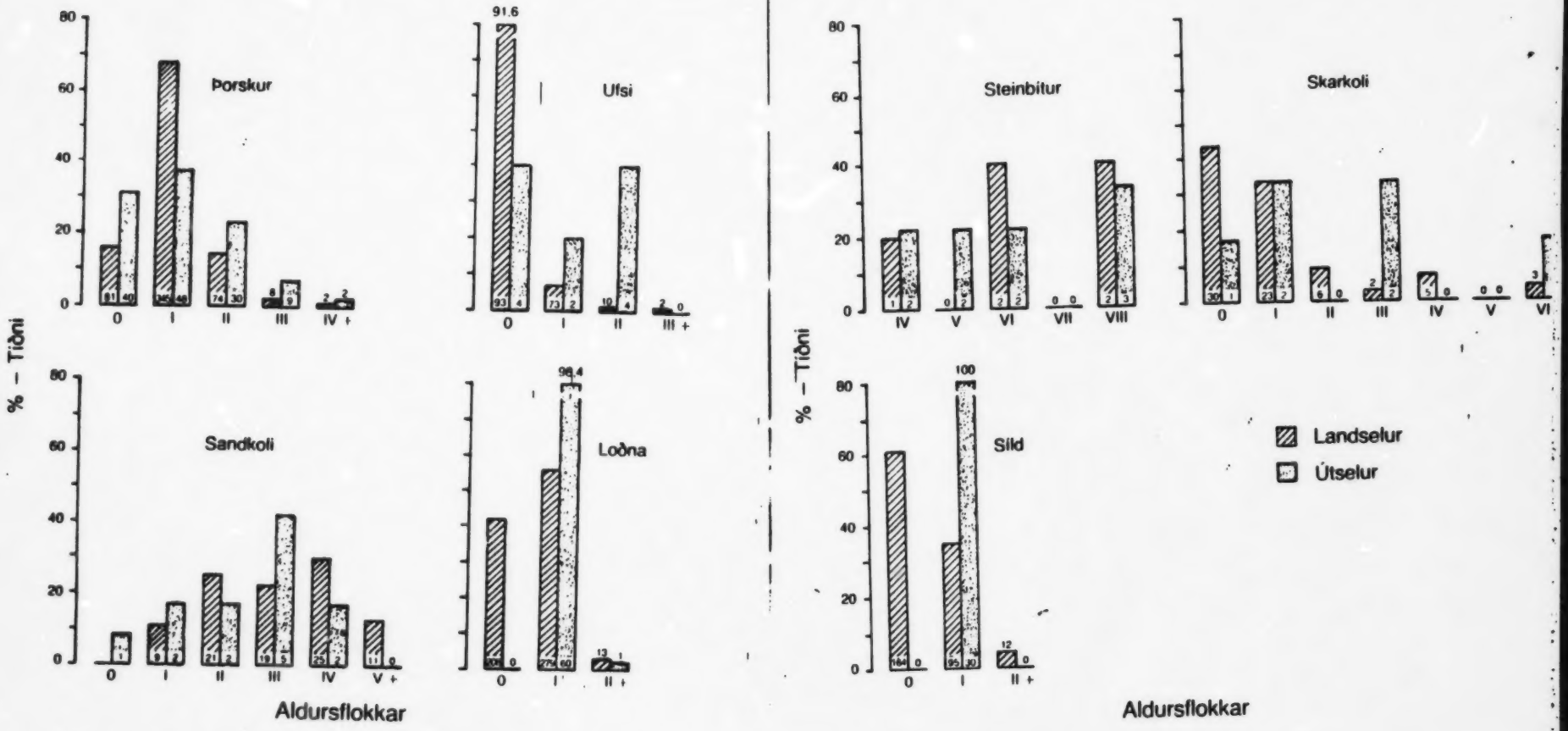
Fig. 2.



2. mynd. Hlutfallsleg skipting fæðutegunda landsels og útsels eftir þunga.

Food of common seal and grey seal in terms of percentage in weight. For legends see fig. 1.

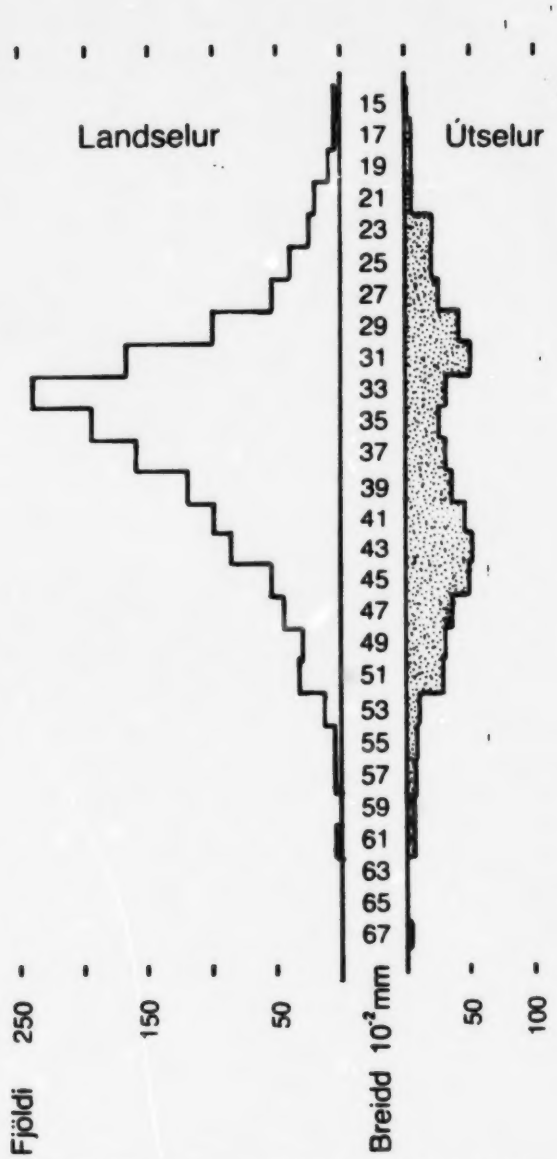
Fig. 3.



3. mynd. Hlutfallsleg skipting algengustu fæðutegunda í aldursflokka.

Frequency distributions of age classes of the most common fish species in the food of seals. For legends see fig. 1.

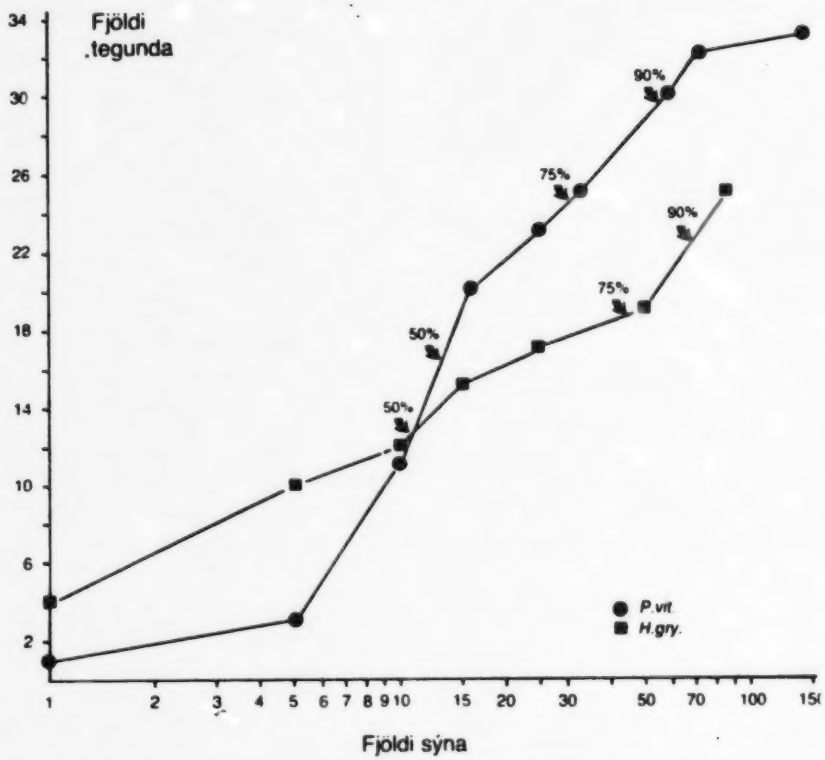
Fig. 4.



4. mynd. Stærðardreifing síliskvarna í fæðusýnum úr landsel og útsel (breidd kvarna var mæld).

Size-distribution of the width of sandeel otoliths, in samples of food from common seals and grey seals.

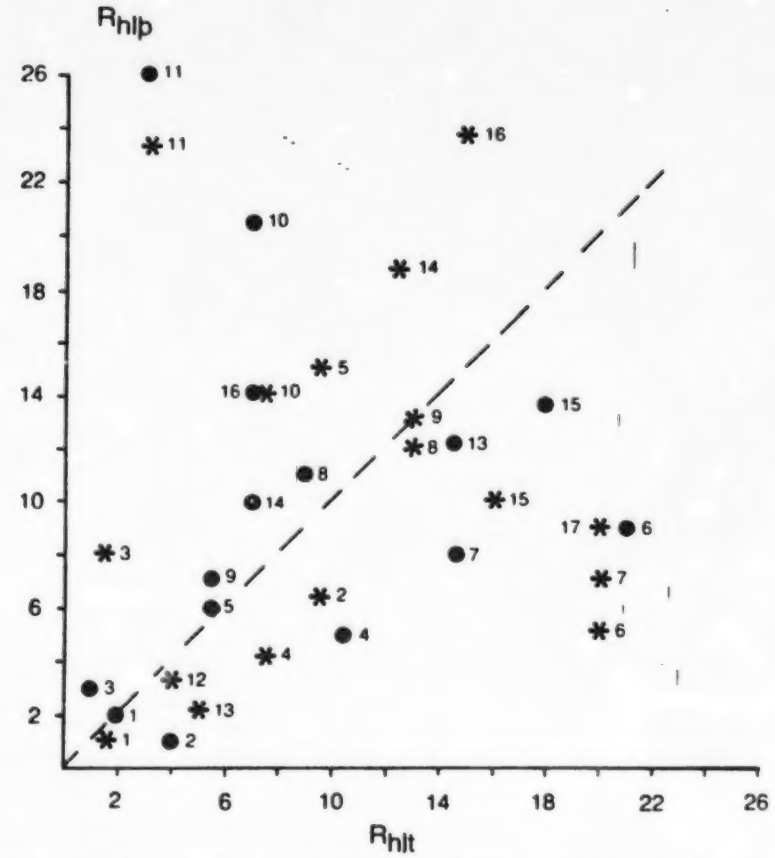
Fig. 5.



5. mynd. Aukning á fjölda fæðutegunda með fjölgun sýna, hjá landsel (*P. vit.*) og útsel (*H. gry.*). Prósentutölur gefa til kynna við hvaða fjölda sýna 50, 75 og 90% tegunda hafa komið fram, miðað við heildarfjölda fæðutegunda, er fundust í fæðusýnum viðkomandi selategundar.

Cumulative distribution of number of species (ordinate) and numbers of samples of food from seals (abscissa). P. vit. common seal. H. gry. grey seal. percental figures on the graph show how many food-species have appeared in relation to number of samples taken, in percentage of the total number of species found in the food of each seal species.

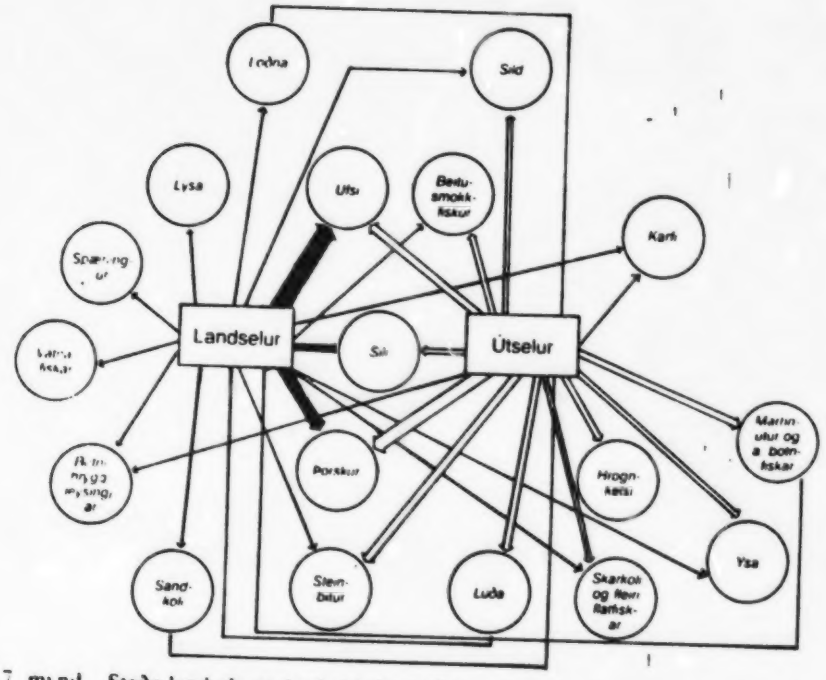
Fig. 6.



6. mynd. Staðsetning algengustu fæðutegunda sela í hnitakerfi, þar sem fæðutegundum er raðað eftir hlutfalli af þunga heildarfæðu ($R_{hlþ}$) eftir y-ás og eftir hlutfallslegri tíðni (R_{hlt}) eftir x-ás. ● er fyrir landsel og * er fyrir útsel. 1 þorskur, 2 ufsi, 3 síli, 4 steinbítur, 5 sandkoli, 6 lúða, 7 síld, 8 skarkoli, 9 loðna, 10 trjónukrabbar, 11 aðrir hryggleysingjar, 12 hrognkelsi, 13 marhnútar, 14 mjónar, 15 ýsa, 16 skerar, 17 beitusmokkur. Þær fæðutegundir, sem hafa hliðstætt vægi í fæðunni sama hvort er um að ræða hlutfallslega tíðni eða þunga, raðast á brotnu línuna á myndinni, sem dregin er gegnum þá punkta þar sem y er sama og x.

*Ranking of the most common species in the food of seals, by weight ($R_{hlþ}$) and by proportional frequency in percentage (R_{hlt}). ● common seal, * grey seal. 1 cod, 2 saithe, 3 sandeel, 4 catfish, 5 dab, 6 halibut, 7 herring, 8 plaice, 9 capelin, 10 Hyas spp., 11 other invertebrates, 12 lumpsucker, 13 Cottidae, 14 Lumpenidae and Zoarcidae, 15 haddock, 16 Sebastes spp., 17 flying squid. Food-species which have the same or similar importance in the foods of seals, by weight and by percent frequency of total food items, lie close to the broken line on the figure, where y = x.*

Fig. 7.



7. mynd. Staða landsels og útsels í fæðuvef Íslandsmiða. Fæðutengslum fisktegunda innbyrðis sleppt. Þykkt örva sýnir hlutfallslegt mikilvægi fæðutengsla eftir þunga.

Trophical relationship of common seals and grey seals, and fish species in Icelandic waters. Arrows width indicates the importance of the fish species in the food of seals by weight. For legends see fig. 1

TABLE 1

TAFLA 1

Dreifing fæðusýna úr selum eftir strandsvæðum og árstíma.

Distribution of foodsamples from seals after coastal areas and time of collection.

Landselur
Common seal

Strandsvæði *Coastal areas*	Fjöldi sýna *Number of samples*						
	Jan Feb	Mar Apr	Maí Jún	Júl Ág	Sep Okt	Nóv Des	Alls *Total*
Faxaflói	4	—	9	2	7	6	28
Breiðafjörður	—	—	7	8	4	—	19
Vestfirðir	2	17	10	—	—	—	29
Strandir–Skagafj. ..	—	11	16	4	—	—	31
Eyjafj.–Þistilfj.	—	3	2	8	—	—	13
Austfirðir	—	—	13	26	17	—	56
Suðurströndin	—	—	7	5	4	1	17
Alls *Total*	6	31	64	53	32	7	193

Útselur
Grey seal

Strandsvæði *Coastal areas*	Fjöldi sýna *Number of samples*						
	Jan Feb	Mar Apr	Maí Jún	Júl Ág	Sep Okt	Nóv Des	Alls *Total*
Faxaflói	—	—	2	—	—	2	4
Breiðafjörður	—	—	12	17	12	2	43
Vestfirðir	1	6	12	4	—	1	24
Strandir–Skagafj. ..	—	1	12	2	—	2	17
Eyjafj.–Þistilfj.	—	—	—	1	—	4	5
Austfirðir	—	—	—	—	4	—	4
Suðurströndin	—	—	—	—	—	—	—
Alls *Total*	1	7	38	24	16	11	97

TABLE 2

TAFLA 2

Yfirlit yfir lengdar-þyngdarsamband fisktegunda í fæðu sela, ásamt veginni meðalþyngd þeirra.
Information on the length-weight relationship of fishspecies in the food of seals, used for calculations of their weight when their length is known.

Fisktegundir *Fishspecies*	Tölugildi stuðlanna a og b í l. – þ sambandinu þ = a · l^b *Values of the coefficients a and b in the l –w relationship w = a · l^b*		Meðalþyngd fisktег. í fæðunni (g) *Meanweight of fishspecies in food (g)*		Heimildir um lengdar- og þyngdar samband fiska, og lengdar- eða þyngdarvöxt í þeirra. *References*
	a · 10^2	b	Landselur *Common seal*	Útselur *Grey seal*	
Þorskur 0–2 ára *Cod 0–2 years*	5.93	3.121	74	188	Ólafur K. Pálsson, 1979
Þorskur 2 ára[1] *Cod 2 years*		–			Sigfús Schopka, persl. uppl.
Ufsi ..... *Saithe*	--	--	97	413	Anon, 1981
Ýsa 0–2 ára ... *Haddock 0–2 years*	6.11	3.143	35	595	Ólafur K. Pálsson, 1979
Ýsa >2 ára .... *Haddock >2 years*	10.04	3.001			Anon, 1981
Lýsa ..... *Whiting*	4.78	3.178	127	—	Ólafur K. Pálsson, 1979
Spærlingur ..... *Norway pout*	9.6	3	50	—	Viðar Helgason, persl. uppl.
Steinbítur[1] ..... *Catfish*	—	—	1260	1133	Gunnar Jónsson, 1982
Loðna[1] ..... *Capelin*	—	—	5	6	Anon, 1981
Síld[1] ..... *Herring*	—	—	20	28	Anon, 1981
Skarkoli ..... *Plaice*	9.04	3.078	76	142	Aðalsteinn Sigurðsson, persl. upp. og (1956)
Sandkoli ..... *Dab*	—[2]	—[2]	90	58	Gunnar Jónsson, 1986
Lúða ..... *Halibut*	10.7	3	399	2991	Aðalsteinn Sigurðsson, 1971
Skrápflúra .... *Long rough dab*	6.0	3	35	5	Bjarni Sæmundsson, 1926[3]
Þykkvalúra .... *Common sole*	10.0	3	13	138	Bjarni Sæmundsson, 1926[3]

[1] Upplýsingar um þyngdarvöxt fyrir hendi.
Growth by weight is known.

[2] Somu stuðlar notaðir og hjá skarkola, vegna skorts á sambærilegum stuðlum fyrir sandkola.
Same values on a and b used as with plaice, due to lack of information on these for dab.

[3] Lengdar-aldurssamband áksarðað frá upplýsingum í bók Bjarna Sæmundssonar, Fiskarnir.
Length-age relationship determined from information from Bjarni Sæmundsson 1926.

TABLE 3

TAFLA 3

Meðalþungi fæðutegunda í selasýnum, annarra en getið er í töflu 2 ásamt upplýsingum um aðferðir við ákvörðun hans.

Meanweight of foodspecies in samples from seals, others than in Table 2.

Fæðutegundir *Foodspecies*	Meðalþungi fæðutegunda (g) *Meanweight of foodspecies (g)*		Aðferð við ákvörðun
	Landselur *Common seal*	Útselur *Grey seal*	
Hrognkelsi *Lumpsucker*	500	500	Sjá bls. 29
Síli[1] *Sandeel*	2	2,5	Sjá bls. 29
Marhnútar[2] *Sea scorpions*	200	200	Sjá bls. 31
Stórkjafta *Megrim*	65	—	Áætlun
Sprettfiskur *Rockeel*	7	7	Sjá bls. 31
Mjónar[3] *Blennies*	10	10	Áætlun
Löngur[4] *Ling*	10	—	Áætlun
Laxfiskar *Salmonids*	50	—	Stærð kvarna
Strendingar *Agonidae*	20	—	Áætlun
Karfi *Red fish*	65	65	Sjá bls. 29
Hornsíli *Stickleback*	5	—	Áætlun
Skötur *Hyperotremata*	200	200	Áætlun
Óákvarðaðir fiskar *Unidentified fishes*	5	5	Áætlun
Beitusmokkur *Fourspot squid*	400	400	Sjá bls. 31
Rækjur *Pandalids*	5	5	Áætlun
Kuðungakrabbi *Lupaeonus spp*	50	50	Áætlun
Trjónukrabbi *Hyas spp*	50	50	Áætlun
Beitukóngur *Buccinum spp*	50	—	Áætlun
Skerar *Nereis*	5	5	Áætlun
Aðrir hryggleysingjar *Other small invertebr.*	1	1	Áætlun

[1] Marsíli, sandsíli og trönusíli tekin saman. *Ammodytidae.*

[2] Fiskar af marhnútaætt teknir saman. *Cottidae.*

[3] Mjónar og mjórar. *Lumpenidae and Zoarcidae.*

[4] Löngur og skyldar tegundir. *Gadus, Molva and Rhinonemus spp.*

TABLE 4

TAFLA 4

Fæðutegundir í meltingarvegi sela, safnað 1979–1982, eftir strandsvæðum. Aðeins 5 algengustu fæðutegundir á hverju svæði eru teknar með í töflunni. N tjöldi sýna með fæðuleifum, Σf_i heildartíðni fæðutegunda.

Foodspecies of seals, samples collected 1979–1982, after coastal areas. The 5 most common foodspecies in each area are shown in the table. N number of samples with remains of food, Σf_i total occurences of foodspecies.

	Landselur *Common seal* Hlutfallsleg tíðni 95% ö.m. *Proportional frequency 95% c.l.*		Útselur *Grey seal* Hlutfallsleg tíðni 95% ö.m. *Proportional frequency 95% c.l.*	
Faxaflói	N = 27, Σf_i = 78		N = 4, Σf_i = 14	
Síli *Sandeel*	21,8	13,6–32,7	Þorskur *Cod*	21,5	4,7–46,3
Ufsi *Saithe*	17,9	10,4–28,7	Ýsa *Haddock*	14,4	1,8–39,1
Þorskur *Cod*	9,0	3,8–17,6	Hrognkelsi *Lumpsucker*	7,1	0,4–31,6
Sandkoli *Dab*	6,4	2,0–13,7	Sandkoli *Dab*	7,1	0,4–31,6
Ýsa *Haddock*	6,4	2,0–13,7	Ufsi *Saithe*	7,1	0,4–31,6
Breiðafjörður	N = 19, Σf_i = 87		N = 36, Σf_i = 104	
Síli *Sandeel*	18,4	10,7–27,6	Síli[1] *Sandeel*	16,3	9,6–24,4
Þorskur *Cod*	11,5	6,1–20,6	Hrognkelsi *Lumpsucker*	14,4	8,0–22,2
Skarkoli *Plaice*	7,0	2,7–14,5	Þorskur *Cod*	9,6	5,0–17,4
Skerar *Scrods*	7,0	2,7–14,5	Marhnútar[2] *Sea Scorpions*	8,8	4,3–16,2
Kuðungakrabbar *Lupaeonus spp*	7,0	2,7–14,5	Skarkoli *Plaice*	3,8	1,2–9,8
Vestfirðir	N = 27, Σf_i = 109		N = 23, Σf_i = 74	
Þorskur *Cod*	15,6	9,7–24,2	Þorskur *Cod*	17,6	10,2–28,5
Síli[1] *Sandeel*	13,8	8,1–21,9	Hrognkelsi *Lumpsucker*	12,2	5,8–21,5
Loðna *Capelin*	9,2	5,1–17,2	Sandkoli *Dab*	6,8	2,5–15,3
Ufsi *Saithe*	6,5	2,4–12,2	Síli[1] *Sandeel*	6,8	2,5–15,3
Sandkoli *Dab*	5,5	2,4–12,2	Steinbítur *Catfish*	5,4	1,4–12,6

[1] Marsíli, sandsíli og trönusíli tekin saman. *Ammodytidae*

[2] Fiskar af marhnútaætt teknir saman. *Cottidae*

TAFLA 4 (framh.)

	Landselur *Common seal* Hlutfallsleg tíðni 95% ö.m. *Proportional frequency 95% c.l.*		Útselur *Grey seal* Hlutfallsleg tíðni 95% ö.m. *Proportional frequency 95% c.l.*	
Strandir–Skagafj.	**N = 26, Σ f_i = 59**		**N = 17, Σ f_i = 47**	
Síli[1] *Sandeel*	30,5	18,9–43,2	Þorskur *Cod*	21,3	10,8–34,8
Þorskur *Cod*	22,0	12,0–34,5	Síli[1] *Sandeel*	19,2	9,3–32,6
Loðna *Capelin*	10,2	3,8–20,5	Steinbítur *Catfish*	10,6	3,9–23,1
Steinbítur *Catfish*	5,0	1,1–14,0	Marhnútar[2] *Sea Scorpions*	6,4	1,3–16,9
Karfar *Red-fish*	3,4	0,4–11,1	Hrognkelsi *Lumpsucker*	4,3	0,5–14,1
Eyjafj.–Þistilfj.	**N = 10, Σ f_i = 26**		**N = 5, Σ f_i = 12**	
Síli[1] *Sandeel*	26,9	11,6–47,5	Síli[1] *Sandeel*	33,4	10,2–61,5
Loðna *Capelin*	15,4	4,4–34,7	Hrognkelsi *Lumpsucker*	16,7	2,1–46,3
Þorskur *Cod*	7,7	0,9–25,0	Þorskur *Cod*	8,3	0,2–37,1
Sandkoli *Dab*	7,7	0,9–25,0	Loðna *Capelin*	8,3	0,2–37,1
Mjónar[4] *Blennies*	7,7	0,9–25,0	Mjónar[4] *Blennies*	8,3	0,2–37,1
Austfirðir	**N = 20, Σ f_i = 36**		**N = 4, Σ f_i = 7**	
Síli[1] *Sandeel*	19,4	8,3–35,2	Síli[1] *Sandeel*	28,5	3,7–61,0
Þorskur *Cod*	13,9	4,7–28,9	Þorskur *Cod*	14,3	0,4–51,1
Sandkoli *Dab*	8,3	1,8–22,1	Ufsi *Saithe*	14,3	0,4–51,1
Ufsi *Saithe*	5,6	0,7–18,4	Lúrur[3] *sole fammie*	14,3	0,4–51,1
Mjónar[4] *Blennies*	5,6	0,7–18,4	Kuðungakrabbar *Eupagurus spp*	14,3	0,4–51,1

[1] Marsíli, sandsíli og trönusíli tekin saman. *Ammodytidae*
[2] Fiskar af marhnútaætt teknir saman. *Cottidae*
[3] Þykkvalúra og langlúra. *Lemon sole and witch taken together*
[4] Fiskar af mjóna- og mjóraætt teknir saman. *Fishes of genus Lumpenidae and Zoarcidae*

TAFLA 4 (framh.)

	Landselur *Common seal* Hlutfallsleg tíðni 95% ö.m. *Proportional frequency 95% c.l.*		Útselur *Grey seal* Hlutfallsleg tíðni 95% ö.m. *Proportional frequency 95% c.l.*
Suðurströndin	**N = 11, Σ f_i = 20**		
Síli *Sandeel*	40,0	19,1–64,0	
Lýsa *Whiting*	15,0	3,2–37,9	
Þorskur *Cod*	10,0	1,2–31,7	*„Sýni skortir"* *Samples are lacking*
Sandkoli *Dab*	5,0	0,1–24,8	
Spærlingur *Norway pout*	5,0	0,1–24,8	

Marsíli, sandsíli og trönusíli tekin saman. *Ammodytidae*

TABLE 5

TAFLA 5

Fæðutegundir í sýnum úr meltingarvegi sela, safnað 1979–1982, eftir árstímum. Nánari skýringar í töflu 4

Foodspecies from seals, collected 1979–1982, by time of year. For further legends see table 4.

	Landselur *Common seal* Hlutfallsleg tíðni 95% ö.m. *Proportional frequency 95% c.l.*		Útselur *Grey seal* Hlutfallsleg tíðni 95% ö.m. *Proportional frequency 95% c.l.*	
Jan.–feb.	N = 6, Σf_i = 17		N = 1, Σf_i = 4	
Ufsi *Saithe*	29,4	10,5–54,4	Þorskur *Cod*	25,0	0,5–71,6
Þorskur *Cod*	11,8	1,4–35,7	Sandkoli *Dab*	25,0	0,5–71,6
Loðna *Capelin*	5,9	0,2–28,2	Loðna *Capelin*	25,0	0,5–71,6
Sandkoli *Dab*	5,9	0,2–28,2	Síld *Herring*	25,0	0,5–71,6
Síli[1] *Sandeel*	5,9	0,2–28,2	—	—	—
Mars–apr.	N = 29, Σf_i = 105		N = 7, Σf_i = 18	
Þorskur *Cod*	19,0	12,0–27,8	Hrognkelsi *Lumpsucker*	22,2	6,5–45,9
Síli[1] *Sandeel*	15,2	8,8–23,3	Þorskur *Cod*	16,7	3,6–40,1
Loðna *Capelin*	12,4	6,5–19,7	Sandkoli *Dab*	11,1	1,4–33,7
Ufsi *Saithe*	5,7	2,3–12,4	Síli[1] *Sandeel*	11,1	1,4–33,7
Síld *Herring*	5,7	2,3–12,4	Rækja *Pandalids*	11,1	1,4–33,7
Maí–júní	N = 51, Σf_i = 114		N = 36, Σf_i = 92	
Síli[1] *Sandeel*	29,8	21,8–39,2	Þorskur *Cod*	19,6	12,4–29,6
Þorskur *Cod*	13,2	7,5–30,5	Hrognkelsi *Lumpsucker*	15,2	8,4–23,9
Trjónukrabbar *Hyas spp*	5,3	1,8–10,7	Síli[1] *Sandeel*	15,2	8,4–23,9
Ufsi *Saithe*	4,4	1,3–9,4	Steinbítur *Catfish*	7,6	2,5–18,1
Steinbítur *Catfish*	4,4	1,3–9,4	Marhnútar[2] *Sea scorpions*	3,3	0,6–8,8

[1] Marsíli, sandsíli og trönusíli tekin saman. *Ammodytidae.*

[2] Fiskar af marhnútaætt teknir saman. *Cottidae.*

TABLE 5 (CONT.)

TAFLA 5 (framh.)

	Landselur *Common seal* Hlutfallsleg tíðni 95% ö.m. *Proportional frequency 95% c.l.*		Útselur *Grey seal* Hlutfallsleg tíðni 95% ö.m. *Proportional frequency 95% c.l.*	
Júlí–ágúst	N = 29, Σf_i = 92		N = 23, Σf_i = 68	
Síli ..... *Sandeel*	21,7	14,1–28,6	Hrognkelsi ..... *Lumpsucker*	13,2	6,2–23,9
Þorskur ..... *Cod*	9,8	4,8–18,0	Þorskur ..... *Cod*	11,8	5,5–22,0
Sandkoli ..... *Dab*	6,5	2,8–14,2	Síli[1] ..... *Sandeel*	11,8	5,5–22,0
Skarkoli ..... *Plaice*	4,3	1,0–10,3	Skarkoli ..... *Plaice*	5,9	1,8–14,5
Mjónar[1] ..... *Blennies*	4,3	1,0–10,3	Trjónukrabbar ..... *Hyas spp*	5,9	1,8–14,5
Sept.–okt.	N = 21, Σf_i = 68		N = 9, Σf_i = 42	
Síli[1] ..... *Sandeel*	22,1	13,0–33,5	Síli[1] ..... *Sandeel*	16,7	7,9–30,3
Þorskur ..... *Cod*	13,2	6,2–22,0	Þorskur ..... *Cod*	7,1	1,5–19,0
Sandkoli ..... *Dab*	13,2	6,2–22,0	Ufsi ..... *Saithe*	7,1	1,5–19,0
Ufsi ..... *Saithe*	4,4	0,8–11,7	Marhnútar[2] ..... *Sea scorpions*	7,1	1,5–19,0
Lýsa ..... *Whiting*	4,4	0,8–11,7	Kuðungakrabbar .... *Eupagurus spp*	7,1	1,5–19,0
Nóv.–des.	N = 6, Σf_i = 19		N = 11, Σf_i = 34	
Ufsi ..... *Saithe*	31,6	12,9–53,5	Síli[1] ..... *Sandeel*	20,6	8,7–37,3
Ýsa ..... *Haddock*	10,5	1,3–32,0	Þorskur ..... *Cod*	14,7	4,9–30,6
Síli[1] ..... *Sandeel*	10,5	1,3–32,0	Ufsi ..... *Saithe*	11,8	3,3–27,1
Skerar ..... *Nerds*	10,5	1,3–32,0	Marhnútar[2] ..... *Sea scorpions*	8,8	1,9–23,4
Þorskur ..... *Cod*	5,3	0,1–25,3	Ýsa ..... *Haddock*	5,9	0,7–19,5

[1] Marsíli, sandsíli og tronusíli tekin saman. *Ammodytidae.*

[2] Fiskar af marhnútaætt teknir saman. *Cottidae.*

[3] Fiskar af mjóna- og mjóraætt teknir saman. *Lumpenidae und Zoarcidae*

TABLE 6.

TAFLA 6

Niðurstöður könnunar með G-prófun, á því hvort tíðni fæðutegunda sé háð strandsvæðum og árstíma.

Results of G-tests on independence of occurrences of foodspecies with coastal areas and time of year.

Fæðutegundir *Foodspecies*	G_{adj}	df	Strandsvæði *Coastal areas* Svæði þar sem fæðutegund er tíðust *Most common in*	G_{adj}	df	Árstími *Time of year* Árstími er fæðutegund er tíðust *Most common in*
LANDSELUR *COMMON SEAL*						
Síli ..... *Sandeel*	11.14	6		11.47[1]	5	Maí–júní
Þorskur .... *Cod*	6.30	6		4.95	5	
Ufsi ..... *Saithe*	22.73[1]	4	Faxaflói	24.63[1]	4	Jan.–feb.; mars–apríl
Sandkoli ... *Dab*	2.44	5		13.37[2]	4	Sept.–okt.
Loðna ..... *Capelin*	23.75[1]	3	Eyjafj.–Þistilfj.	14.64[2]	3	Mars–apríl
Steinbítur .. *Catfish*	3.48	4		2.91	2	
Skarkoli ... *Plaice*	7.16[1]	2	Breiðafjörður	2.25	4	
Síld ..... *Herring*	5.90	3		9.29[2]	2	Jan.–feb.; mars–apríl
ÚTSELUR *GREY SEAL*						
Síli ..... *Sandeel*	8.97	5		2.05	4	
Þorskur .... *Cod*	4.84	5		4.35	5	
Hrognkelsi . *Lumpsucker*	4.00	4		11.44[1]	4	Mars–apríl; maí–jún
Steinbítur .. *Catfish*	52.28[3]	2	Strandir–Skagafj.	5.51[1]	2	Maí–júní

[1] $p<0,05$.

[2] $p<0,01$.

[3] $p<0,001$.

[4] Tvö tímabil ársins eru gefin upp þegar tíðnin er u.þ.b. jafn há. Það tímabil með lægri tíðni e það síðara.

The frequency of foodspecies are about the same in the two periods. Given in order of magnitude.

TABLE 7

TAFLA 7

Dreifing fæðusýna hjá landsel og útsel, eftir fjölda fæðutegunda.
Number of foodspecies found in samples of food from common seals and grey seals.

Fjöldi fæðutegunda *Number of foodspecies*	Landselur *Common seal*		Útselur *Grey seal*	
	Fjöldi sýna *No of samples*	% sýna með x fæðuteg. og færri *% cumulative*	Fjöldi sýna *No of samples*	% sýna með x fæðuteg. og færri *% cumulative*
1	42	30,0	20	23,5
2	37	56,4	23	50,5
3	21	71,4	18	71,7
4	17	83,5	14	88,2
5	9	89,9	7	96,4
6	7	94,9	1	97,6
7	3	97,0	0	97,6
8	3	99,1	1	98,8
9	0	99,1	1	100,0
10	1	100,0	—	—
Alls *Total*	140		85	
Meðalfjöldi *Mean*	2,8		2,8	
Fervik *Variance*	3,49		2,50	

TABLE 8

TAFLA 8

Samanburður á tíðni einstakra fæðutegunda í sýnum úr landsel og útsel, með G-prófun, sjá einnig 1. mynd.
Comparison of frequency of foodspecies in common seals and grey seals, with G-tests of independence.

Fæðutegundir *Foodspecies*	G_{adj}	Marktækur munur *Significant difference*	Tíðni hærri í *Freq. higher in*
Síli *Sandeel*	4.51	$p<0.05$	Landsel *Common seal*
Þorskur *Cod*	0.20	÷	
Hrognkelsi *Lumpsucker*	43.78	$p<0.001$	Útsel *Grey seal*
Ufsi *Saithe*	2.20	÷	
Sandkoli *Dab*	0.93	÷	
Loðna *Capelin*	4.51	$p<0.05$	Landsel *Common seal*
Steinbítur *Catfish*	1.12	÷	
Skarkoli *Pluice*	0.35	÷	
Síld *Herring*	1.50	÷	
Trjónukrabbar *Eupagurus spp.*	0.76	÷	
Kuðungakrabbar *Hyas spp.*	0.06	÷	
Skerar *Nerids*	1.81	÷	

TABLE 9

TAFLA 9

Breytingar í hlutföllum helstu fæðutegunda hja landsel og útsel með aukningu a fjölda syna. Sýni eru valin a tilviljanabundinn hátt ur synasafninu hjá hvorri selategund.

Changes in percentage of the most common foodspecies of common seal and grey seal, with increasing number of samples. Samples are randomly picked out from the collection of foodsamples from each sealspecies.

Fæðutegundir *Foodspecies*	Fjöldi syna *Number of samples*										Alls *Total*
	1	2	3	4	5	7	10	15	26	50	
A Hlutfallsleg tíðni fæðutegunda *Frequency of the total*					**LANDSELUR** ***COMMON SEAL***						
Ufsi *Saithe*	0.0	0.0	0.0	5.6	16.7	10.5	4.8	6.2	5.7	5.5	6.0
Þorskur *Cod*	0.0	11.1	0.0	16.7	0.0	10.5	23.8	16.7	15.3	15.8	13.5
Síli *Sandeel*	100.0	22.2	66.7	5.6	66.7	26.3	28.6	16.7	25.0	22.6	21.2
Aðrar *Other foods*	0.0	66.7	33.3	72.1	16.6	52.7	42.8	60.4	54.0	56.1	59.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
					ÚTSELUR ***GREY SEAL***						
Þorskur *Cod*	25.0	20.0	22.2	25.0	17.6	19.0	14.8	17.9	19.4	17.9	14.7
Ufsi *Saithe*	0.0	0.0	0.0	0.0	0.0	0.0	3.7	5.1	4.8	4.2	3.5
Marhnútar *Sea Scorpions*	0.0	20.0	11.1	8.3	5.9	9.5	7.4	5.1	3.2	3.2	4.6
Hrognkelsi *Lumpsucker*	0.0	0.0	0.0	0.0	5.9	9.5	7.4	10.2	12.9	10.5	11.2
Steinbítur *Catfish*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	6.4	6.3	3.9
Aðrar *Other foods*	75.0	60.0	66.7	66.7	70.6	62.0	66.7	54.8	53.3	57.9	62.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Fæðutegundir *Foodspecies*	Fjöldi syna *Number of samples*										Alls *Total*
	1	2	3	4	5	7	10	15	26	50	
B Hlutfall af heildarþunga *Proportion by weight (%)*					**LANDSELUR** ***COMMON SEAL***						
Ufsi *Saithe*	0.0	0.0	0.0	5.0	75.8	21.3	1.4	4.5	7.9	34.9	33.4
Þorskur *Cod*	0.0	72.8	0.0	15.6	0.0	10.8	11.7	33.7	38.7	25.3	23.9
Síli *Sandeel*	100.0	2.1	86.1	0.1	21.9	13.4	26.6	1.5	10.9	8.5	9.9
Aðrar *Other foods*	0.0	25.1	13.9	79.3	2.3	54.5	60.3	60.3	42.5	31.3	32.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
					ÚTSELUR ***GREY SEAL***						
Þorskur *Cod*	80.7	70.6	72.9	38.7	29.0	29.2	15.7	14.0	17.5	18.4	22.0
Ufsi *Saithe*	0.0	0.0	0.0	0.0	0.0	0.0	14.4	14.6	12.4	15.0	8.1
Marhnútar *Sea Scorpions*	0.0	12.5	11.1	4.1	3.1	5.2	2.8	1.3	1.0	3.0	12.6
Hrognkelsi *Lumpsucker*	0.0	0.0	0.0	0.0	7.7	12.9	7.0	6.4	10.0	8.3	11.9
Steinbítur *Catfish*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	14.2	15.0	11.1
Aðrar *Other foods*	19.3	16.9	16.0	57.2	60.2	52.7	60.1	56.4	44.9	40.3	34.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 10

TAFLA 10

Flokkun fæðutegunda sela eftir lífshættum.
Division of foodspecies of seals after habitats

Skipting í flokka *Groups of foodspecies*	Fæðutegundir í flokkum *Representative foodspecies for each group*	Hlutfallsleg tíðni *Proportional frequency*	
		Landselur *Common seal*	Útselur *Grey seal*
Uppsjávarfiskar *Pelagic fishes*	Ufsi, loðna, síld o.fl. *Saithe, capelin, herring a.o.*	13,9	6,2
Uppsjávarhryggleysingjar *Pelagic invertebrates*	Beitusmokkur *Flying squid*	0,5	0,7
Botnlægir fiskar *Demersal fishes*	Síli, þorskur, hrognkelsi, karfi o.fl. *Sandeel, cod, lumpsucker, redfish a.o.*	37,7	41,0
Botnfiskar *Benthic fishes*	Ýsa, steinbítur, flatfiskar o.fl. *Haddock, catfish, flatfishes a.o.*	25,0	24,9
Botnhryggleysingjar *Benthic invertebrates*	Krabbar, beitukóngur o.fl. *Crabs, Buccinum spp. a.o.*	19,3	21,7
Botnþörungar *Benthic algae*		3,6	5,4
		100,0	100,0